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L4: Entry 7 of 13   File: USPT   Feb 2, 1999

DOCUMENT-IDENTIFIER: US 5867411 A
TITLE: Kalman filter ionospheric delay estimator

Brief Summary Text (5):
Parameter estimators have been used to generate parameters estimates of parameters
estimated from an input. Bias estimators have been used to generate bias esitmates
of bias of an input. The parameter estimators and bias estimators are methods
having many possible applications. One such application is range determination of
the Gobal Positioning System (GPS) generating pseudoranges which are affected by
potential bias, ionospheric propagation delays and phase ambiguities producing
ranging errors. GPS receivers are used to acquire position on ground, in air or in
space based upon the reception of satellite signals transmitted from the GPS
satellite constellation. From the GPS satellite transmit antenna, the satellite
signals propagate through free space, the ionosphere and the troposphere to the GPS
receiver. The GPS constellation consists of 24 satellites operating in twelve-hour
orbits at an altitude of 20,183 km and provides visibility of six to eleven
satellites at elevations of five degrees or more above the horizon to users located
anywhere in the world at any time. The navigation signals from the satellites
consist of two rf frequencies, L.sub.1 at 1575.42 MHz and L.sub.2 at 1227.6 MHz.
The L.sub.1 and L.sub.2 signals are modulated by pseudo-random noise (PN) or
spread-spectrum (SS) codes and are also modulated with the navigation data-stream
at 50 bps carrying various navigation messages. The signals transmitted from
different satellites occupy the same rf bandwidth on a Code Division Multiple
Accessing (CDMA) basis. In the CDMA techniques, different PN codes are assigned to
different satellites and the receiver matches these codes with like reference codes
generated in the receiver through cross-correlation technique implemented in Delay
Lock Loops (DLLs). Individual DLLs are assigned to different satellites being
tracked by the receiver in a parallel approach or a single loop is shared in a time
division mode among many satellites in a single channel and less expansive
receivers. In addition to making it possible to separate signals from different GPS
satellites, the PN codes also make it possible to measure the range to the
satellite by measuring the signal propagation delay from the satellite to the GPS
receiver by measuring the relative phase of the received signal code phase with the
local reference code phase. The accuracy with which such a propagation delay can be
measured depends upon the PN code chip rate, the latter directly determining the rf
bandwidth of the spread spectrum modulated signal. The measurement accuracy of the
propagation delay is equal to a fraction of the PN code chip period, that is, the
inverse of the code chip rate. The actual fraction depends upon the various details
of receiver implementation and various sources of errors. Each GPS satellite has
two codes assigned to it, a distinct C/A code with a chip rate of 1.023 MHz and a
P-Code with different offsets and with a chip rate of 10.23 MHz. The L.sub.1 signal
is modulated with both the P and C/A codes in phase quadrature and the L.sub.2
signal is modulated with the P-Code. ·

Detailed Description Text (5):
The bank of Kalman filters 16 is used to resolve ambiguities. In the state space
formulation, x (k) represents the state vector at the kth update discrete time
interval. The range equations may be rewritten in compact form by an x (k) vector
definition state equation, a z(k) vector measurement state equation, a z(k) vector
measurement definition state equation and a vector observation noise definition ·

h   e b   b g ee e f   e   b   b c e

state equation all four of which are collectively referred to as state equations which use an H matrix defined by an H Matrix equation. ##EQU2##

Detailed Description Text (26):
In the presence of bias, the z (k) vector measurement equation is replaced by a modified observation vector equation using a b matrix equation.

Detailed Description Text (27):
Observation Vector Equation

h   e b   b g ee e f   e   b   b c e